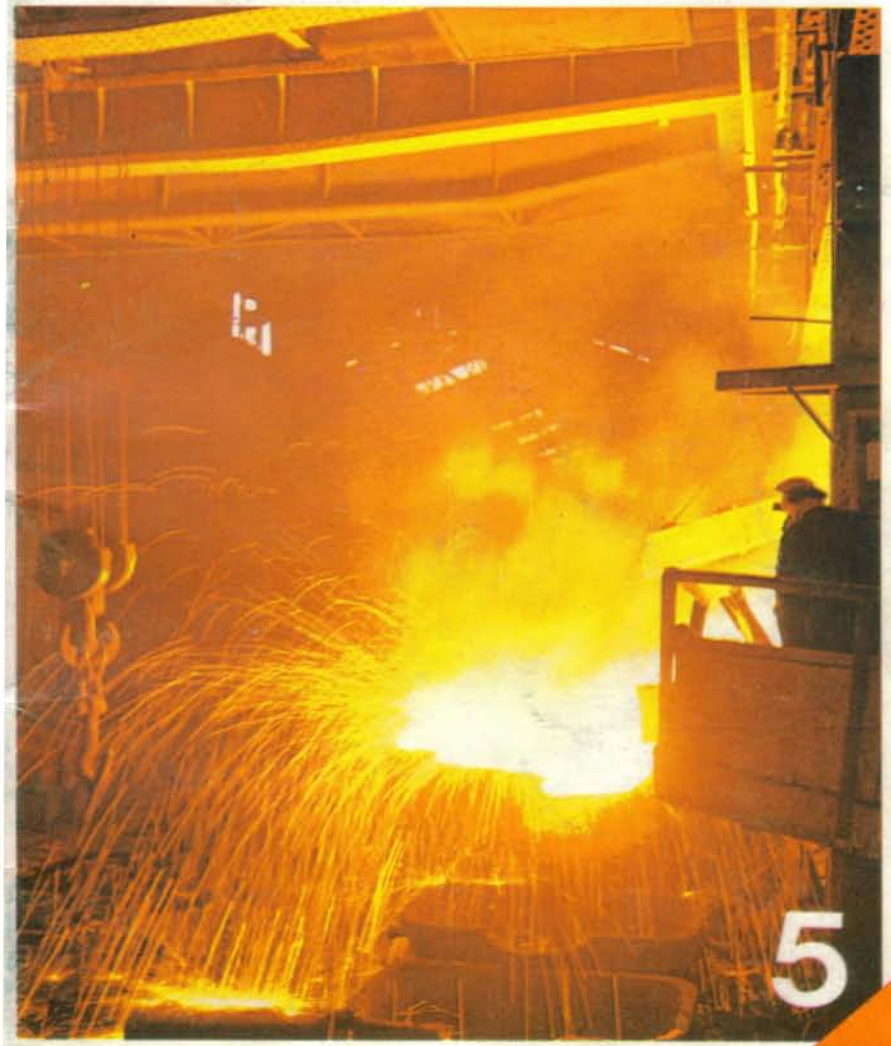
BASIC SCIENCE SERIES



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HEAT

REVISED EDITION

BASIC SCIENCE SERIES — BOOK 5

REVISED EDITION

HEAT

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INTRODUCTION

Can you imagine how cold the Earth would be if there were no Sun? The Sun is the Earth's main source of heat. Only a little of the Sun's heat reaches the Earth. However, this is enough for life to exist on Earth. All living things need warmth in order to live. The heat from the Sun provides us with this warmth.

The sun gives us heat.

Man gets warmth from the sun and the food he eats. Man also makes his own heat. When he is cold he makes a fire to warm himself. He makes clothes to cover himself. He uses heat to cook his food and to light his house.

OUR BODIES CONTAIN HEAT

How can we show that our bodies contain heat? Open your mouth wide and breathe on your hands. Is the air from your body warm or cold?

WHAT GIVES HEAT?

1. The **sun** gives us heat. Touch a tin that has been in the sun for some time. It feels hot. Place the tin inside the house. Touch the tin after some time. It feels cold.

The heat from the sun can be used to burn paper.

Use a magnifying glass to focus sunlight on a piece of white paper. What happens to the piece of paper at the position where the sunlight is focused? It becomes hot, starts to turn brown and soon bursts into flame. Thus the heat from the sun makes the paper burn.

Heat is produced by burning wood.

2. Man can make heat by burning wood, coal and gas. Wood, coal and gas are called **fuels**. Man burns fuels to keep himself warm. He also burns fuels in machines to make them work. A motor-car runs by burning fuel. An aeroplane flies by burning fuel.

3. **Electricity** also gives heat. Man uses electricity to cook his food and to work his machines. How many things in your house and school are worked by electricity? Name them. How many of these things give out heat?

It is easy to find out whether electricity gives heat or not. Put your hand near a lighted bulb. What do you feel? Touch a radio which has been switched on for some time. What do you feel?

4. Heat can be made by **rubbing** two things together. Rub the palms of your hands together. What do you feel? Take your ruler and rub it up and down the edge of a table. Rub the ruler many times. Then put the ruler against your hand. You will feel that it is hot.

HOW DO WE MEASURE HEAT?

We can measure the length and the width of this book. We can also measure our height and our weight.

Do you know that hotness can be measured too? We can measure the hotness of our bodies. We can tell if we are sick by measuring the hotness of our bodies.

Things to Do

Take three basins. Fill the first basin with water which is as hot as you are able to bear with your hands. In the second basin mix hot water with cold water. This is **lukewarm** water. Fill the third basin with cold water from the tap.

Place the basins on the table as shown in the picture. Put your right hand in the hot water. Put your left hand in the cold water. You will find that your right hand feels hot and your left hand feels cold. After twenty seconds move both your hands into the lukewarm water. What do you feel? Your left hand feels warm and your right hand feels cold. But both hands are in the same basin of water! You cannot really tell if a thing is hot or cold by feeling it.

Can you tell whether the water is hot or cold by feeling it?

We use a ruler to measure length and breadth. To measure hotness we use a **thermometer**.

We use a doctor's thermometer to measure the heat of our body.

doctor's thermometer

You can see a thermometer in the picture. This is a doctor's thermometer. The boy keeps his mouth closed over the thermometer until it reaches the temperature of his body.

Hotness or coldness is called **temperature.** If the boy is sick and his body is very hot, we say that his temperature is 'high'. If the day is cold we say that the temperature is 'low'. Why do we say 'high' temperature and 'low' temperature?

Look carefully at the picture of the room thermometer. It is made of a hollow glass tube or stem, with a hollow glass bulb at the base. In the bulb there is a liquid called **mercury**. The thermometer is fixed to a wooden scale which like your ruler is marked with lines.

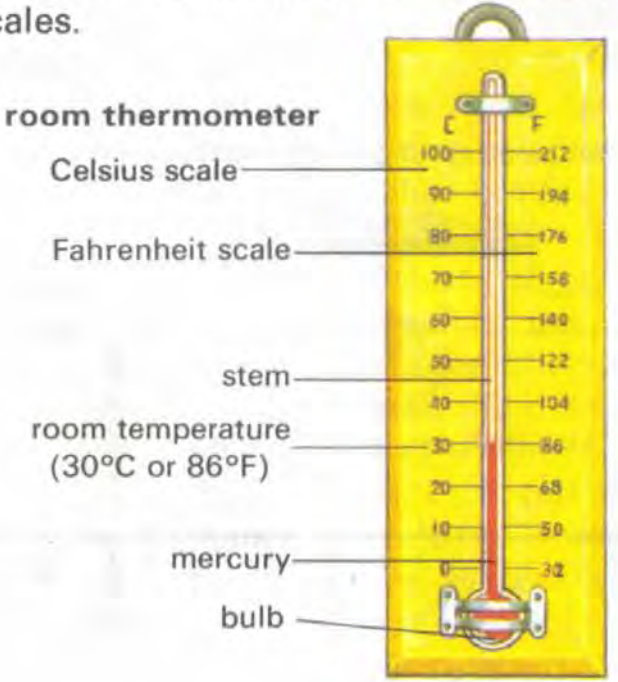
Heat makes the mercury rise in the hollow glass stem. The hotter it is, the higher this mercury will rise. Therefore we say the temperature is 'high'. When it is cold the mercury in the stem will sink. So we say the temperature is 'low'.

Look at the picture of the room thermometer again. How high has the mercury risen in the stem? By reading the scale we know how hot the room is.

We measure length with a ruler. We can measure length in two different ways — in centimetres and in inches.

We measure temperature with a thermometer, in **degrees Celsius**. 'C' stands for Celsius. Some thermometers use a different scale — the **Fahrenheit scale**. The picture shows a thermometer with both Celsius and Fahrenheit scales.

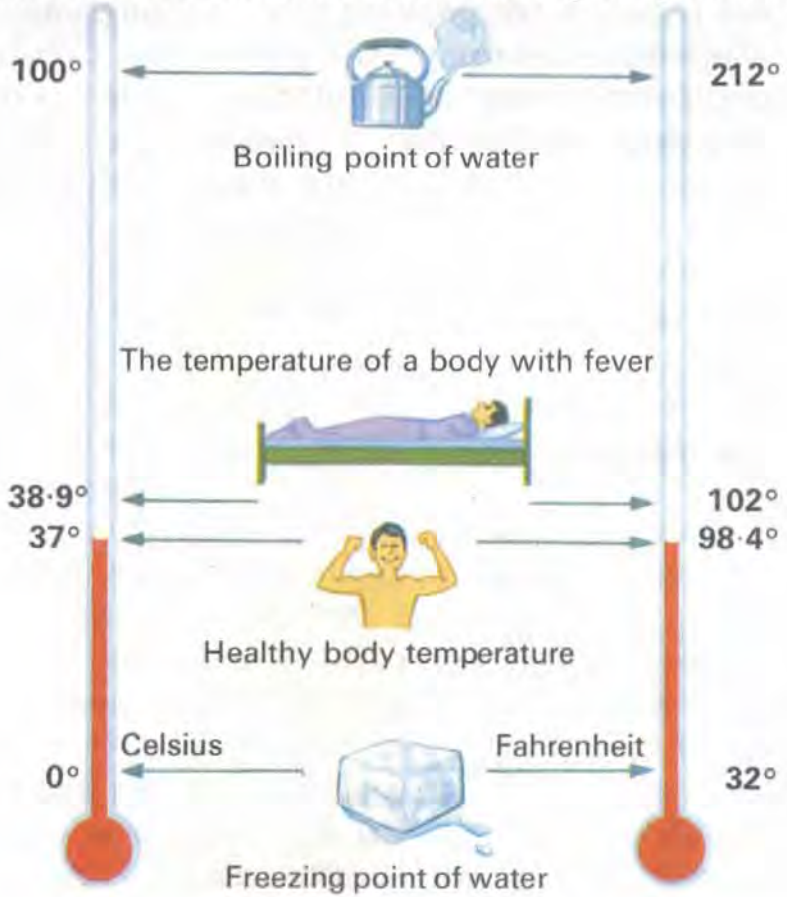
A room thermometer



You will find that the Celsius scale rises from 0° to 100°. On the Celsius scale, 0° shows the temperature at which water freezes, that is, turns into ice. 100° shows the temperature at which water boils.

The Fahrenheit scale rises from 32° to 212°. On the Fahrenheit scale, 32° shows the temperature at which water freezes and 212° shows the temperature at which water boils.

Thermometers are used for measuring temperatures.



EXPANSION AND CONTRACTION

Expansion means to become bigger and therefore to take up more space. Contraction means to become smaller and therefore to take up less space.

What happens to the water level in the tube when water expands?

Things to Do

Fill a small bottle with water. Colour the water by adding a drop or two of ink and shake the bottle. Get a cork which will fit the mouth of the bottle tightly. Make a hole through the cork. Push a tube through the hole in the cork. You can use the plastic tube of a ball-point pen. Cap the bottle with the cork.

Put your bottle in a pot of hot water. What happens? Mark on the tube the point to which the water has risen. Now place the bottle in ice-cold water. What happens?

The water in the bottle expands when the bottle is placed in a pot of hot water. Therefore the water rises in the tube, thus occupying more space. When the bottle of water is placed in a pot of ice-cold water, the water in the bottle contracts. This causes the water level in the tube to drop, since the water now occupies less space.

HEAT MAKES THINGS EXPAND

You have seen how a thermometer measures hotness. When it is hot the mercury rises in the stem of the thermometer. The hotter it is, the higher the mercury rises. This is because heat makes things expand.

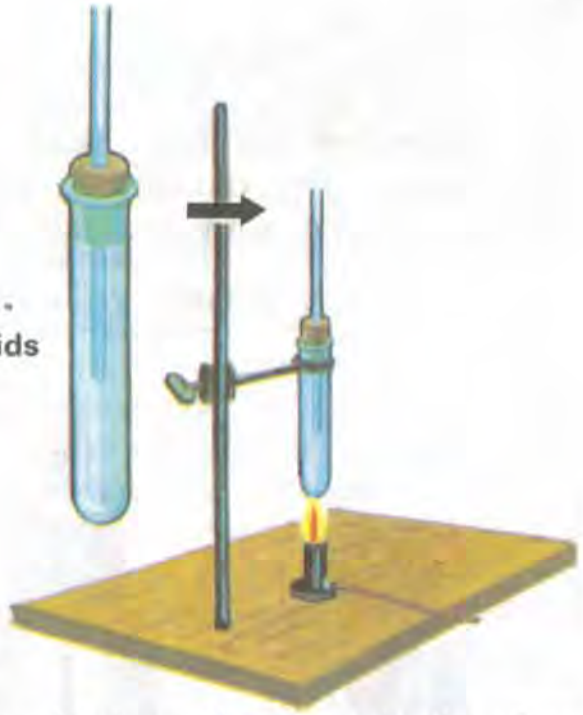
When it is cold the mercury in the stem of the thermometer goes down. This is because coldness or loss of heat makes things contract.

HEAT MAKES LIQUIDS EXPAND

If you fill a kettle with water right up to the brim and then put it over a fire, the water will overflow as it becomes hot. This is because liquids expand when heated.

Things to Do

Fill a test tube with water mixed with ink. Next, push a 15 cm glass tube into a cork or a rubber stopper which will fit the test tube tightly. When you fit the cork or stopper into the test tube,



Heat makes liquids expand.

the water will rise a little way in the glass tube. Mark on the glass tube the level to which the water has risen.

Next, hold the test tube over a flame. Do not wait for the water to boil. Does the water rise in the glass tube? What happens when the water cools?

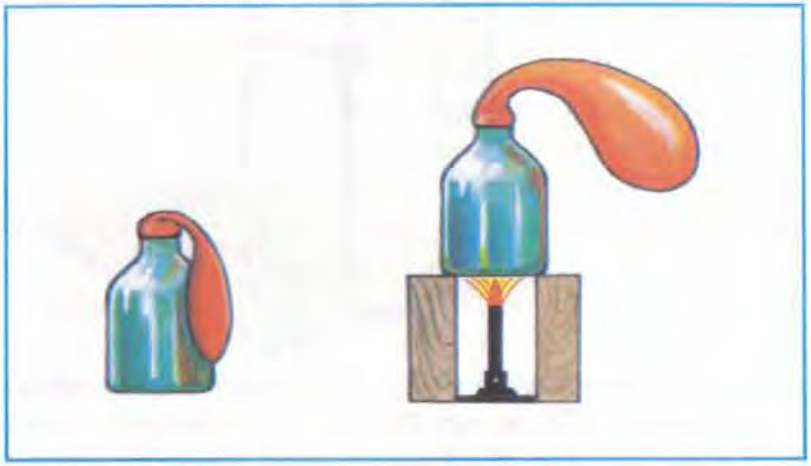
HEAT MAKES GASES EXPAND

You have seen how water expands when it is heated and contracts when it is cooled. All liquids do this. Will air which is a mixture of gases do the same thing? Will it expand when it is heated and contract when it is cooled?

Things to Do

Stretch a balloon over the neck of an empty bottle. Remember that air is all around us and that it is also present in the bottle. The outside air cannot get into the bottle now.

Heat makes air expand.



Place the bottle over a flame or inside some hot water. The air inside the bottle will expand when it gets hot. It will rise into the balloon and fill it. Now let the bottle cool. What do you think will happen to the balloon?

HEAT MAKES SOLIDS EXPAND

You have seen how liquids and gases expand when they are heated and contract when they are cooled. Will solids do the same thing?

Heat makes solids expand.

Things to Do

Stretch a wire tightly across an open window. Weight it down in the middle with a brick. Measure the distance of the brick from the window sill with a ruler. Heat the wire with a lighted candle. Move the candle flame back and forth along the wire.

When the wire is heated it will expand and become longer. It will sag in the middle. Measure the distance of the brick from the window sill now.

When the wire cools it will contract and become tight again. This shows that a solid expands when it is heated and contracts when it cools.

HEAT MAKES GASES MOVE UPWARDS

You have learned that gases expand when they are heated. Expanding means getting bigger and this results in movement. In which way do heated gases move? They move upwards.

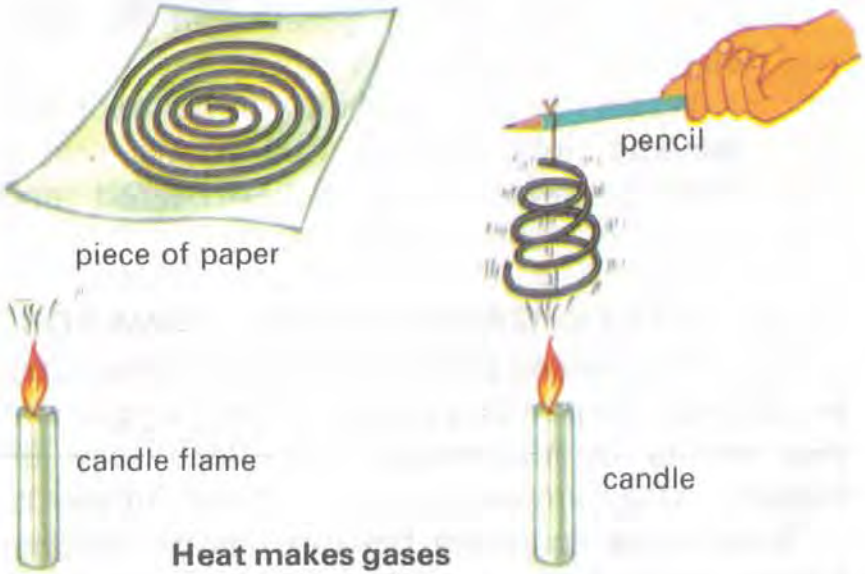
They move upwards because gases become lighter or less dense when they are heated.

This is because the same weight of a gas which occupied a smaller space before heating, occupies a larger space after heating. Cooler air from above, which is more dense, moves under the heated air and pushes it up.

Things to Do

Draw a spiral on a piece of paper and cut it out as shown in the picture. Tie one end of a piece of thread to the centre of the paper spiral. Tie the other end of the thread to a pencil.

Hold the spiral over a candle flame. The hot air will rise from the candle flame and make the spiral move. Take away the candle flame. Will the spiral still move?



Heat makes gases move upwards.

HEAT MAKES LIQUIDS MOVE UPWARDS

Like gases, liquids also expand and move upwards when they are heated. Heated liquids will move upwards because they become lighter or less dense. Cooler liquid from above, which is more dense, moves under the heated liquid and pushes it up.

Heat makes liquids move upwards.

The hot coloured water in the ink bottle rises to the surface of the big jar.

The cold water in the big jar sinks to the bottom of the ink bottle.

Things to Do

Take a small empty ink bottle and cover it tightly. The cover must carry two glass tubes as shown in the picture. Fill the bottle with very hot water that has been coloured strongly with ink. Wipe the outside of the ink bottle.

Fill a large glass jar with very cold or icy water. Place the ink bottle quickly on the bottom of this jar of very cold

water. What do you think will happen? The hot coloured water in the ink bottle will rise through the tall glass tube. It will rise to the surface of the cold water in the big jar. This shows that when liquids become hot, they become less dense and rise.

What happens to the cold water in the big jar? The cold water is denser than the hot water and will sink through the other glass tube into the ink bottle. Therefore hot liquids rise and cold liquids sink.

HEAT TRAVELS FROM ONE PLACE TO ANOTHER

Heat always moves or travels from a warmer place to a cooler place. It moves or travels from places of high temperature to places of low temperature.

Heat moves or travels in three different ways: **conduction, convection and radiation.**

CONDUCTION

When heat travels through something, without making this thing move, it is said to travel by **conduction**. Anything through which heat travels in this way is called a **conductor** of heat.

Hold a metal spoon to a candle flame. The heat from the flame will pass through the spoon to your fingers. The spoon is conducting heat from

the flame to your fingers. The metal spoon is therefore a conductor of heat.

Some things or materials will conduct heat better than others. These materials are said to be **good conductors**.

Metals like iron, tin, aluminium and copper are good conductors of heat. This is why frying pans, cooking pots and kettles are made of metal.

Materials that conduct heat slowly are said to be **bad conductors**. Some bad conductors are cloth, wood and rubber. These bad conductors are used to prevent us from getting burned. When they are used in this way they are called **insulators**. Wooden handles on kettles, ladles and pots act as insulators. They protect our hands from getting burned.

Things to Do

(i) You can show that heat travels from warmer things to colder things. Take two ice cubes of the same size. Put one on the table. Hold the other in your hand.

The heat from your hand will melt the ice cube in it. This shows that the heat in your hand is travelling to the ice cube which is colder than your hand. Your hand is therefore losing heat to the ice cube. Your hand will become colder.

The ice cube on the table will also melt. This is because the warmer air around it is

losing heat to the ice cube and melting it. Why does the ice cube in your hand melt more quickly than the ice cube on the table?

(ii) Fix a lump of candle wax to the head of a nail. Hold this nail with a strip of paper. Put the point of the nail to a candle flame. Heat from the candle flame will travel through the nail to the wax and melt it.

The nail is a good conductor of heat. The paper is a bad conductor of heat. If you use the paper to hold the nail you will not get burned.

To show that heat travels from a warmer place to a colder place

(iii) You can show how heat travels through a good conductor. Take a long metal knitting needle. Fix beads along the needle with candle wax. Now use a book to clamp the needle as shown in the picture. Put a lighted candle underneath the other end. As the heat passes from the hotter

Is a knitting needle a good conductor?

end of the needle to the cooler end, it will melt the wax. The beads will drop off one by one. Which one do you think will drop off first? Write down the time it takes for each bead to fall.

(iv) You can find out which things are good conductors and which are bad conductors of heat in this way. Fill a can with hot water. Put into it a pencil, a nail, a glass rod and a metal spoon. Feel the tops of these articles. Which one conducts heat best? The pencil is made of wood. Is it a good or bad conductor? Is the glass rod a good conductor? Are the nail and metal spoon good conductors?

CONVECTION

Heat not only travels by conduction but also by **convection**. When heat travels by convection, it also moves from a warmer place to a cooler place.

In conduction, heat passes through solids like a nail, spoon or wire. In convection, heat is carried by moving gases like air and by moving liquids like water.

Moving air always carries heat from a place of

Convection air currents

higher temperature to a place of lower temperature. A movement of air which carries heat from a warmer place to a cooler place is called a **convection current.** There are convection currents, too, in liquids like water. **Convection water currents** move in the same way as **convection air currents**. They move from a warmer place to a cooler place.

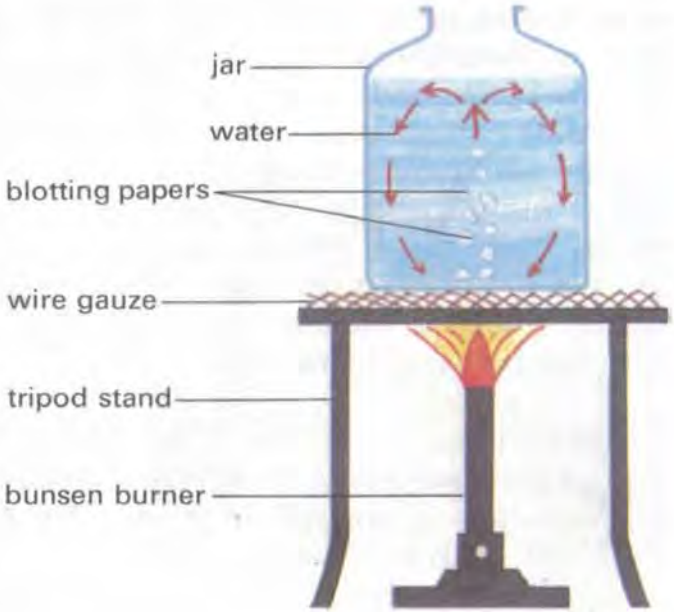
Things to Do

Fill a tall jar with some cold tap water. Put small pieces of blotting paper into the water. Let them sink to the bottom of the jar.

Now put the jar over a small flame. The flame will heat the water at the bottom of the jar. This heated water will expand, become lighter and rise. You cannot, of course see it move upwards. But you can see the small pieces of blotting paper moving up because they are being carried by the warm water as it rises.

The pieces of blotting paper then come down when the colder, heavier water at the top of the jar sinks. The movement of the blotting papers indicates the flow of convection currents. A continuous movement of water is set up as long as the jar of water is heated. Once the flame is removed the convection currents stop.

To find out about convection water currents



RADIATION

Heat not only travels by conduction and convection but also by **radiation**. In radiation no solids, liquids or gases are needed to carry heat.

Heat from the sun comes to us by radiation. It travels through millions of kilometres of space to reach the Earth. There is nothing in this space, not even air, to conduct the sun's heat to us. The sun really gives out what is known as **radiant energy**. This radiant energy can pass through air or glass without making it very warm. But when it is taken in or absorbed by things like rocks, soil and clothes, it makes them warm. We cannot see radiant energy. We can only feel it.

White, shiny objects do not absorb as much radiant energy as black, dull objects. A white shirt is therefore cooler to wear on a hot day than a black one.

Almost all things give out some radiant energy. A table, a chair, a ball and a book all absorb radiant energy, and give it out again. The hotter the object, the more radiant energy it gives out. At this moment your body is giving out radiant energy. The more radiant energy you give out, the cooler you become.

Things to Do

(i) Take two tins. Paint the outside of one black and the other shiny. Fill both the tins with tap water and leave them in the sun for some time. Test the hotness of the water in both tins. Which tin absorbs more heat?

(ii) Use the same tins and fill both with hot water. Put the palms of your hands close to each tin one at a time. Which radiates more heat?

HEAT MAKES THINGS CHANGE

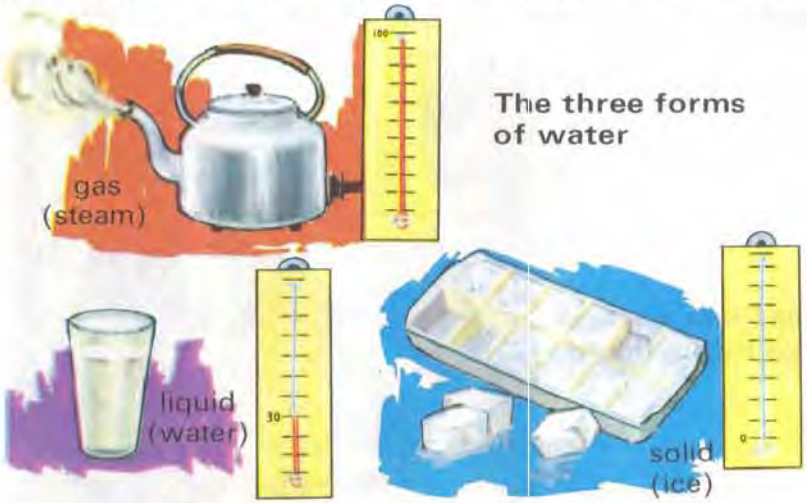
Things around us can be found as **solids**, as **liquids**, and as **gases**. Heat can change a thing which is a solid into a liquid. It can also change a thing which is a liquid into a gas.

When solids change into liquids they are said to **melt**. The temperature at which a certain solid melts is known as the **melting point** of that solid. Different solids melt at different temperatures. Some solids like candle wax melt at a low temperature. Some solids like iron will only melt when they are very hot.

Heat can change iron into a liquid.

When liquids change into gases rapidly at a fixed temperature, they are said to **boil**. The temperature at which a certain liquid boils is known as the **boiling point** of that liquid. Different liquids boil at different temperatures. Methylated spirit needs only a little heat before it turns into a gas. Water needs a lot more heat to turn into a gas.

If a pot of water is left in the open for several hours, the amount of water in the pot will decrease. This is because some of the water has changed into gas and escaped into the atmosphere. This changing of liquids into gases without boiling is known as **evaporation**. Evaporation takes place at any temperature and at all times. The heat needed for evaporation comes from the water itself, the container and the surrounding air. Some liquids evaporate faster than water.



The three forms of water

Can you recognize the solid and liquid forms of water?

Things to Do

Wet a piece of cloth in methylated spirit and another in water. Hang the two pieces of cloth to dry in the sun. Which piece of cloth dries faster? Why?

Take three similar wide-mouthed jam bottles. Half-fill the first bottle with water, the second with oil and the third with methylated spirit. Mark the level of liquid in each bottle. Place the bottles in the hot sun. After a few hours check the levels of the liquids in the three bottles. Which liquid level has fallen the most? Why?

Put some ice in a small tin. The ice melts into water. Heat the water in the tin until it boils. Hold a dry bottle about 16 centimetres above the tin of boiling water. After some time touch the bottle. The bottle will be wet.

Water becomes a solid called ice at freezing point. When ice melts it changes into a liquid called water. When water boils it changes into a gas called steam. The steam moves upwards. When it touches the cold bottle, it cools and changes into water again. The bottle becomes wet.

What happens when a candle is lighted? The heat changes the solid candle wax near the flame to a liquid which flows down the candlestick. As it flows down, it gets cooler. Its temperature changes and it becomes solid again.

HEAT AND BURNING

Burn a candle under a glass jar. After a short while the bottom of the glass jar is covered with a layer of soot. What is this soot? Where does it come from?

The soot is called **carbon**. Carbon is formed when many things burn. When you burn wood, paper or sugar, you get carbon. These three things come from plants. Many things come from plants and these things when burned give us carbon. Burn the following things: sugar, bread, flour, rice, potato and tea. Examine what is formed when each of these is burned. Does it look like carbon?

Does smoke contain carbon?

Both plants and animals contain a lot of carbon. Burn small pieces of meat or dead worms and insects. What do you get?

When a piece of wood burns away completely only a very small amount of greyish-white substance called **ash** is left behind. All the other substances in the wood are changed to gases.

Things to Do

Half-fill a beaker with ash. Add plenty of water and stir. Filter this liquid. Collect the liquid or **filtrate** that comes through the filter paper. If the filtrate is not clear, filter it again. Place a small amount of filtrate on a tin lid and evaporate it until

Filtering the liquid

no liquid is left on the lid. A whitish substance remains on the lid. Let the lid cool, then taste this substance. Can you guess what it is?

Ash contains many types of salt. These salts were part of the wood. They cannot be changed to gases by burning. How did the carbon and the salts become part of the wood?

The firewood was originally part of a growing plant. Plants make their own food and use it for growth. In the presence of sunlight the green leaves of the plant use carbon dioxide from the air, and water containing salts from the soil for making food. The food contains carbon, which comes from the carbon dioxide, and salts. This food is used for building up the various parts of the plant. When any part of a plant is burned we get carbon first. On complete burning only ash containing salts is left behind.

How did carbon and salts become part of these trees?